Operator Access to Acoustically Networked Undersea Systems through the Seaweb Server

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***Abstract*— The Seaweb server is a suite of software applications for managing the network-layer operations of underwater networks employing acoustic modems [Fletcher, et al., *Proc. Oceans 2001*]. It resides at manned command centers (ashore, afloat, submerged, aloft, or afar) and handles application-layer telemetry with mobile and stationary underwater nodes. The server communicates with the undersea network through gateway nodes, such as moored buoys, surface vehicles, or submarine sonars.**

I. INTRODUCTION

Telesonar is acoustic communications in the undersea environment. Seaweb is an organized network of telesonar modems designed for command, control, communications, and navigation of deployable autonomous undersea systems [1]. A Seaweb server resides at manned command centers and is the operator interface to the undersea network as shown in Figure 1. Data and utility packets travel through the undersea network via routes managed by the server and executed by the undersea network in a distributed fashion. These routes are defined by neighbor and routing tables resident on the networked modems, and may be altered by the server administrator.

The second-generation Seaweb server was developed to provide a seamless operator interface to network undersea systems. It has evolved out of the client's necessity for a robust server that communicates through transparent I/O to telesonar nodes (mobile and stationary), provides mission-critical information to end-users, and archives data/commands in database tables accessed by a web browser.

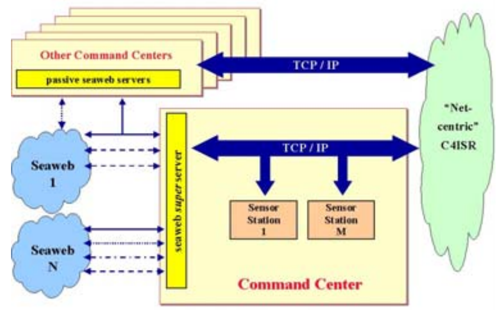

Figure 1. Seaweb extends modern "net-centric" interconnectivity to the undersea realm. Wireless underwater networks include gateway nodes with radio, acoustic, wire, or fiber links to manned command centers where a Seaweb server provides a graphical user interface. At a designated command center a Seaweb "super" server manages the undersea network. All Seaweb servers archive Seaweb packets and provide data access to sensor stations via a database management system [2].

II. DEVELOPMENT

The Seaweb server has been transformed from a suite of proprietary software applications to a suite of open-source software applications developed for the Linux operating system. This transformation has significantly increased the robustness, simplicity, and client-server interface compatibility of the second-generation server.

Previously, the Seaweb server's graphical user interface was a set of Labview virtual instruments [2]. However, due to incompatibility with the MySQL database and a high demand on CPU processing – Labview was replaced by Perl/Tk as a graphical interface. Perl is a script-based programming language, which employs regular expressions for text manipulation, glues several diverse programs together, and provides an interpreter for CGI (Common Gateway Interface) programs that avoids system overhead. Perl/Tk is the Perl graphical front-end toolkit for developing graphical user interfaces.

A MySQL database timestamps, archives and queues all incoming and outgoing data, client information, and network statistics. The database may be accessed/queried using any web browser.

Web integration links the database to the internet with an html form. This permits a client end-user to retrieve and insert telesonar modem data and commands to the undersea network system.

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III. FUNCTIONAL DESCRIPTION

The Seaweb server connects a client end-user to the underwater acoustic network through TCP/IP socket connection. The TCP server, a Perl script, manages the incoming and outgoing message traffic between the Seaweb server and the client as shown in Figure 2.

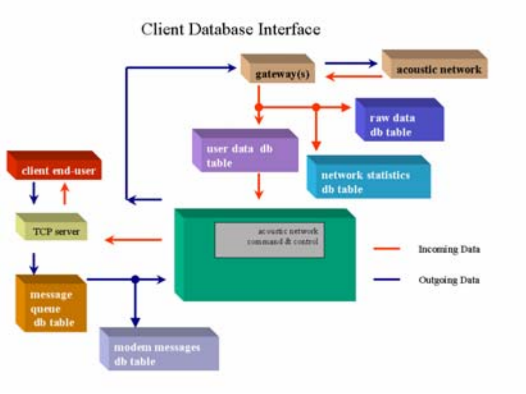


Figure 2. A functional block diagram of the Seaweb server depicting incoming and outgoing data packets from a client to the acoustic network.

Client outgoing data are queued in a message queue database table. After the data packet is archived in the modem messages table, it is sent by the server administrator's message preset prioritization to the acoustic network through a gateway node. The gateway node links the Seaweb server to the undersea network through standard TCP/IP and RS232 serial protocols. Successfully implemented links between the server and the gateway nodes have included FreeWave line-of-sight packet radio, cellular digital packet data (CDPD), Iridium satellite telephone, and US Navy submarine sonar communication systems.

Data packets destined for a client are delivered to the gateway node from a Seaweb of interconnected telesonar modems. After successful delivery from the gateway to the Seaweb server, the data packets are parsed and written to the raw-data, network-statistics, and user-data database tables.

- The raw-data database table receives the unformatted data as it's sent from the gateway node.
- The network-statistics database table stores the status information of each hop that a data packet completes in the undersea network.
- The user-data database table archives client specific data destined for an end-user.

Acoustic network command and control determines which client to send the user data based on his IP address, port number, and source/destination id numbers of the acoustic telesonar modems and the client's Seaweb subscription. After setting up a client/server socket to the TCP server the user data packet is sent from the acoustic network command and control to the client end-user.

IV. OPERATIONAL DESCRIPTION

A. Server Administration

A Linux/Unix shell script is executed to start the Seaweb server. This script queries the server administrator to set up the server to utilize his assets: the acoustic undersea network, clients, and the server's host computer.

The server administrator selects the database location, normally localhost, and the host port number for the TCP server. After these actions, the administrator sets up specific ports (RS232 and TCP/IP) to interface with gateway nodes.

A successful launching of the Seaweb server will display the graphical user interfaces as shown in Figure 3, minus the TcpClient which is shown as an example of a typical client end-user display. All incoming messages are sent to the gateway read-only terminal window and to client displays as they are required. In addition to the graphical gateway display, a time-stamped text log file is initialized for each gateway node as a backup archive to the database.

The heart of the server is the message buffer Perl T/K graphical display – the acoustic network command and control and message queue for outgoing messages. From the message buffer, the administrator prioritizes undersea network activity, selects messages for clients in manual mode or allows FIFO to clients in transparent mode, and views all pertinent information about outgoing messages to the acoustic network.

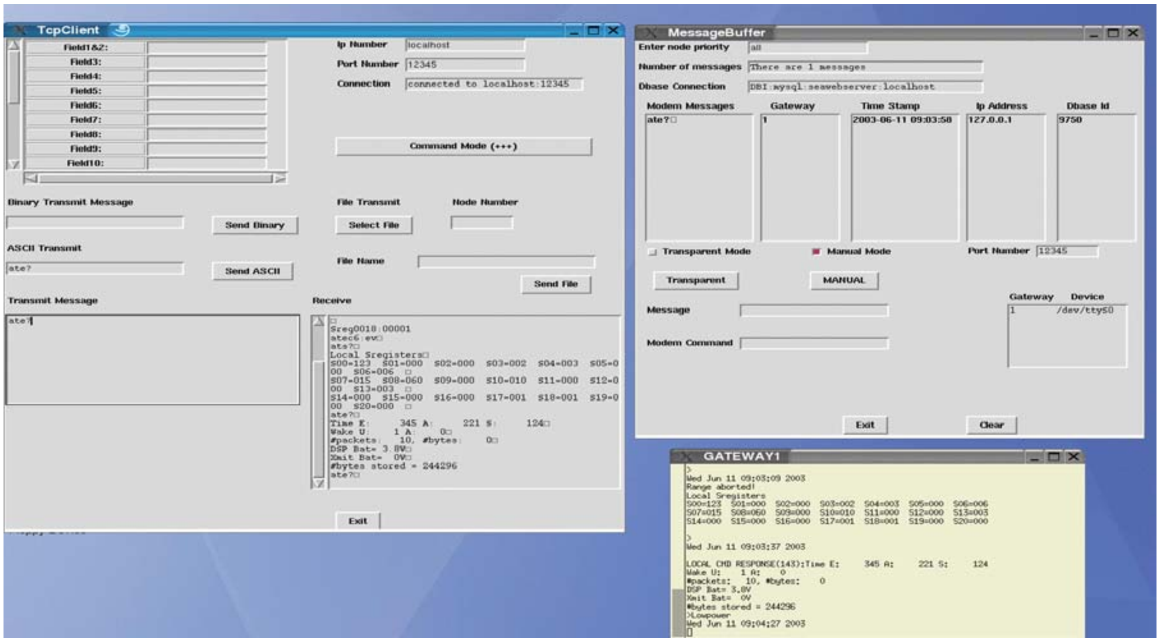


Figure 3. A screen snapshot of the Seaweb server with a client command sent to gateway 1 reading some of the gateway node's S-registers. Note: The TcpClient does not have to be run on the Seaweb server's host computer.

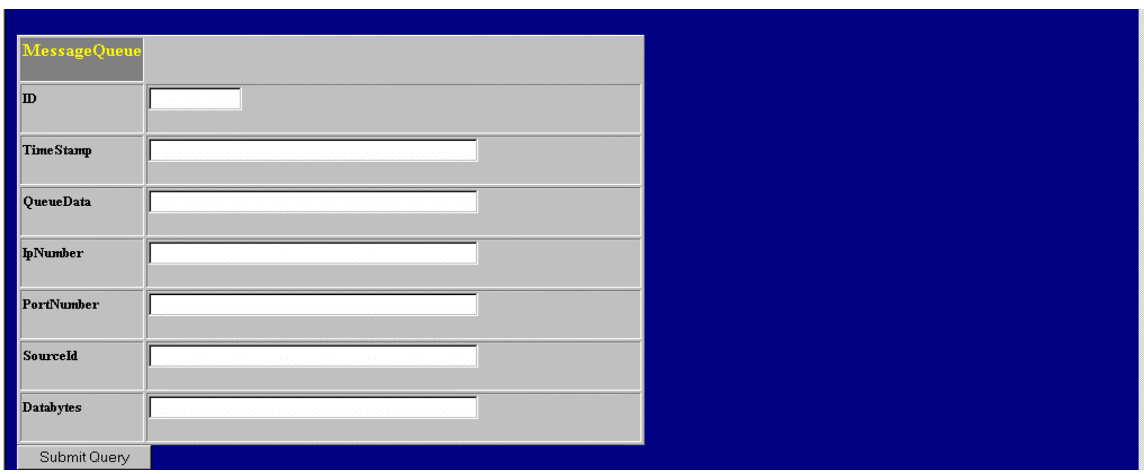


Figure 4. An example of a database table queried from a web browser.

B. Data Retrieval

Client user data are sent directly to the subscribed clients from the Seaweb server as they arrive from the gateway node from the acoustic network. With permission granted by the server administrator, client end-users may query the database for additional archived information. Clients may submit database queries using any web browser. When the client accesses the Seaweb server's main web page, a list of available database tables are displayed along with descriptions of the content of the tables, an example of the message queue database table is shown in Figure 4.

An example of a client end-user's initiated query is shown in Figure 5 with the result posted in Figure 6.

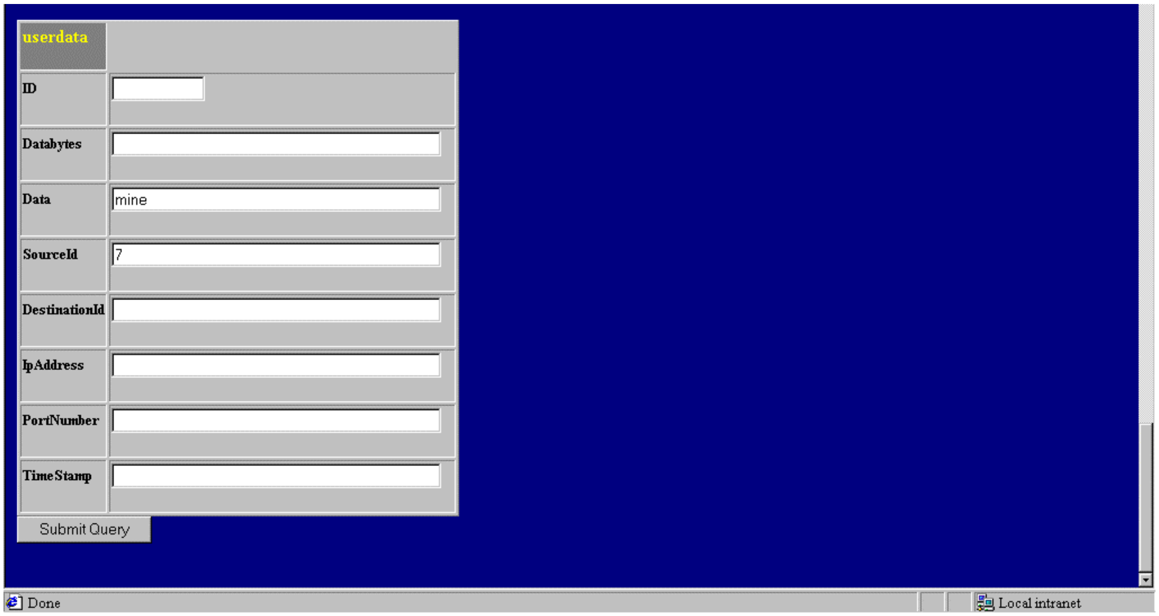
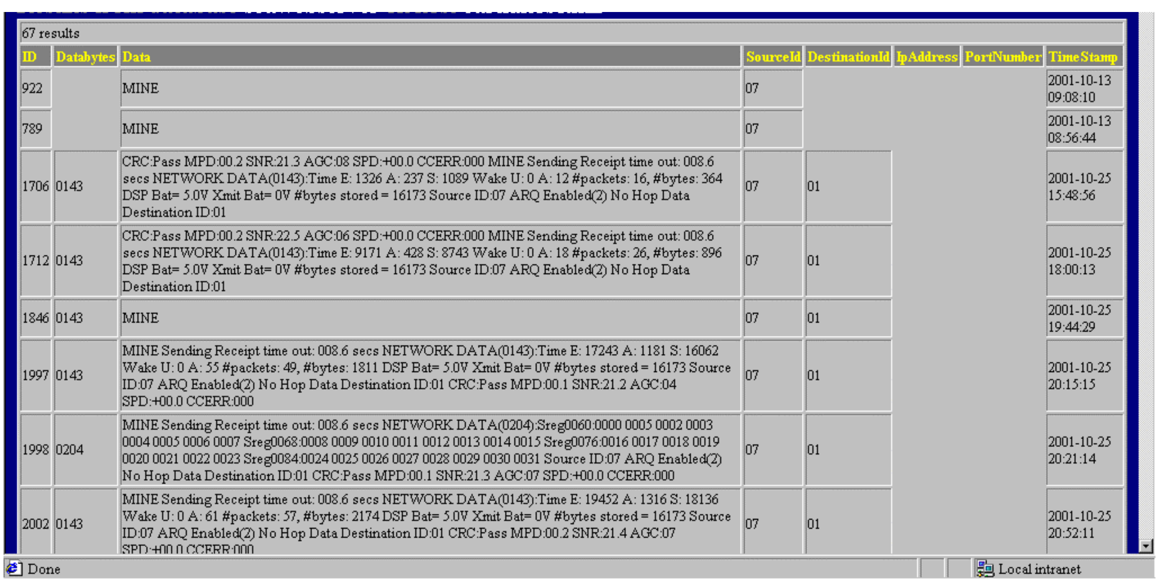


Figure 5. A client query for all user data packets with the word "MINE" coming from node 7 in the undersea network.



67 results

ID	Databytes	Data	SourceId	DestinationId	IpAddress	PortNumber	TimeStamp
922		MINE	07				2001-10-13 09:08:10
789		MINE	07				2001-10-13 08:56:44
1706	0143	CRC:Pass MPD:00.2 SNR:21.3 AGC:08 SPD:+00.0 CCERR:000 MINE Sending Receipt time out: 008.6 secs NETWORK DATA(0143):Time E: 1326 A: 237 S: 1089 Wake U: 0 A: 12 #packets: 16, #bytes: 364 DSP Bat= 5.0V Xmit Bat= 0V #bytes stored = 16173 Source ID:07 ARQ Enabled(2) No Hop Data Destination ID:01	07	01			2001-10-25 15:48:56
1712	0143	CRC:Pass MPD:00.2 SNR:22.5 AGC:06 SPD:+00.0 CCERR:000 MINE Sending Receipt time out: 008.6 secs NETWORK DATA(0143):Time E: 9171 A: 428 S: 8743 Wake U: 0 A: 18 #packets: 26, #bytes: 896 DSP Bat= 5.0V Xmit Bat= 0V #bytes stored = 16173 Source ID:07 ARQ Enabled(2) No Hop Data Destination ID:01	07	01			2001-10-25 18:00:13
1846	0143	MINE	07	01			2001-10-25 19:44:29
1997	0143	MINE Sending Receipt time out: 008.6 secs NETWORK DATA(0143):Time E: 17243 A: 1181 S: 16062 Wake U: 0 A: 55 #packets: 49, #bytes: 1811 DSP Bat= 5.0V Xmit Bat= 0V #bytes stored = 16173 Source ID:07 ARQ Enabled(2) No Hop Data Destination ID:01 CRC:Pass MPD:00.1 SNR:21.2 AGC:04 SPD:+00.0 CCERR:000	07	01			2001-10-25 20:15:15
1998	0204	MINE Sending Receipt time out: 008.6 secs NETWORK DATA(0204):Sreg0060:0000 0005 0002 0003 0004 0005 0006 0007 Sreg0068:0008 0009 0010 0011 0012 0013 0014 0015 Sreg0076:0016 0017 0018 0019 0020 0021 0022 0023 Sreg0084:0024 0025 0026 0027 0028 0029 0030 0031 Source ID:07 ARQ Enabled(2) No Hop Data Destination ID:01 CRC:Pass MPD:00.1 SNR:21.3 AGC:07 SPD:+00.0 CCERR:000	07	01			2001-10-25 20:21:14
2002	0143	MINE Sending Receipt time out: 008.6 secs NETWORK DATA(0143):Time E: 19452 A: 1316 S: 18136 Wake U: 0 A: 61 #packets: 57, #bytes: 2174 DSP Bat= 5.0V Xmit Bat= 0V #bytes stored = 16173 Source ID:07 ARQ Enabled(2) No Hop Data Destination ID:01 CRC:Pass MPD:00.2 SNR:21.4 AGC:07 SPD:+00.0 CCERR:000	07	01			2001-10-25 20:52:11

Done
Local intranet

Figure 6. The result from the client's query. Note: Destination Id is actually the gateway node to which the data packets were routed.

V. SEA TESTING

For the past two years, the Seaweb server has been the primary data gathering source in experiments involving autonomous systems, including FBE-I, RDS-4, and Q-272.

FBE-I Seaweb (June 2001) demonstrated the successful transmission and reception of Naval messages from and to a submarine at speed and depth via the Seaweb server. In addition, the Seaweb server processed telesonar transmissions from two Deployable Autonomous Distributed System (DADS) ASW sensor nodes.

RDS-4 Seaweb (October 2002) demonstrated a variety of underwater sensors as interoperable nodes of a Seaweb network. The network included the U. S. Hydra and Kelp ASW sensors, and the Canadian UCARA sensors.

Q272 Seaweb (February 2003) demonstrated a fleet of three AUVs operating as mobile nodes with a grid of six fixed Seaweb nodes. When surfaced, the AUVs also functioned as Racom gateways with Iridium, FreeWave, ARGOS, and GPS [3].

VI. FUTURE DEVELOPMENT

Current plans for the server include improved graphical interfaces, routing algorithms, AUV tracking functions, and interoperability with other acoustic modems.

Future plans for the server include implementing node localization, mobile node tracking, optimized routing algorithms, and network initialization. Certain of these functions will ultimately migrate into the water in the form of a Seaweb master node capable of controlling a networked field of telesonar modems. The master node communicates with manned command centers via gateway nodes such as a sea-surface buoy radio-linked with space satellite networks, or a ship's sonar interfaced to an on-board Seaweb server.

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